Flexural Behavior of Self Curing Concrete Beam Encased with Steel Section

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Abstract— Self-curing concrete is one of the special concrete in mitigating in-sufficient curing due to human negligence paucity of water in arid area, inaccessibility to structures in difficult terrain and in areas where the presence of fluorides in water will badly affect the various characters of concrete. The present study involves the use of shrinkage reducing admixture polyethylene glycol (PEG 400) which helps in self-curing and for better hydration and strength. Barite powder (BASO4) is used as a partial replacement to fine aggregate of about 30% is used in the self-curing concrete beam and also an hot rolled steel I section is encased in the beam. The flexural behavior of these concrete beams are studied and compared with each other.

Key words: Self Curing Concrete, Polyethylene Glycol, Barite Powder, Encased Steel Section, Flexural Strength

I. INTRODUCTION

Concrete is most commonly used construction material due to its good compressive strength and durability. Depending upon the nature of the work the cement, fine aggregate, coarse aggregate and water are mixed in specific proportions to produce plain concrete. Plain concrete needs favourable atmosphere by providing moisture for a minimum period of 28 days for proper curing and to attain desired strength. The properties of hardened concrete, especially the durability, are greatly influenced by the curing since it has a remarkable effect on the hydration of the cement. Any laxity in curing will affect badly the strength and durability of concrete. Proper curing of concrete structures is important to ensure they meet their required performance and durability requirements. In conventional construction, this is achieved through external curing of concrete after mixing, placing and finishing. Internal curing (IC) is a very promising technique that provides additional moisture in concrete for a more effective hydration of the cement and reduced self-desiccation. Internal curing means an introduction of a curing agent into concrete that will act as an internal source of water.

Concrete with encased steel sections were initially developed in order to overcome the problem of fire resistance and to ensure whether the stability of the steel section was maintained throughout loading. The steel section and concrete act compositely to resist the axial force and bending moments. Composite steel and concrete construction is increasingly used due to the enormous benefits that the bring in terms of load-bearing capacity and seismic and fire resistance of its elements. The basic concept of composite beams lies in the fact that the concrete is stronger in compression than steel and steel is stronger in tension. By utilizing the composite action of these two, the advantages of both materials are utilized to the fullest.

Barite is one of the most commonly used materials as a weighting agent in drilling mud. Barite is used to make high-density concrete in order to block x-ray emissions in hospitals, power plants and other laboratories. Because of its high specific gravity it has an ability to enhance the strength of concrete.

The flexural behavior of the concrete beam both conventional and self-curing are studied with barite as an replacement to fine aggregate and also with steel section encased in the beam and both of these types concrete are compared with each other for detailed study.

II. EXPERIMENTAL PROGRAM

A. Materials

1) Cement

Ordinary Pozzolana Cement (OPC) of 53 grade was used in casting the specimens.

2) Fine Aggregate

River sand of size less than 4.75 mm size were used as fine aggregate.

3) Coarse Aggregate

Hard granite broken stones of less than 20mm size were used as coarse aggregate.

4) Water

Potable water available in laboratory with pH value of not less than 6 and conforming to the requirement of IS 456-2000 was used for mixing concrete and curing the specimen as well.

5) Self-Curing Agent: Poly Ethylene Glycol

Polyethylene glycol is a condensation polymer of ethylene oxide and water with the general formula $H(OCH_2\ CH_2)n\ OH$, where n is the average number of repeating oxyethylene groups typically from 4 to about 180. It appears to be water soluble. It is nontoxic and odourless. The specific gravity is 1.13. The polyethylene-glycol is used to reduce water evaporation from concrete and increase water retention capacity.

6) Barite Powder

Barite is a mineral composed of barium sulfate (BaSO4). It receives its name from the Greek word "barys" which means "heavy". This name is in response to barite's high specific gravity of 4.5, which is exceptional for a non-metallic mineral. The high specific gravity of barite makes it suitable for a wide range of industrial, medical and manufacturing uses. Barite also serves as the principal ore of barium. Barite in size (0–100 µm) is used.

7) Reinforcement

Reinforcement of the beam includes two types of steel reinforcement.

- Longitudinal reinforcement having 4 nos. of 20mm diameter bars and shear reinforcement having 8mm diameter bars placed at a spacing of 200mm c/c.

– The hot rolled steel section of ISMB 100 of 1 meter length is also encased in the beam as reinforcement in the centre of the beam.

Fig. 1: Reinforcement Details

B. Mix Design

Mix design is the process of selecting suitable ingredients for concrete and determining their relative proportion with the object of producing concrete of certain minimum strength and durability by as economical as possible. The mix design is carried out to achieve specified age, workability of fresh concrete and its durability requirements by using IS 10262-2009.

Water	Cement	Fine aggregates	Coarse aggregates
186 lit/m^3	414 kg/ m^3	610.30 kg/ m^3	1172.32 kg/ m^3
0.44	1	2.83	1.47

Table 2.1 Mix Proportion Details

C. Test Specimen

Six beams were casted of dimension 1200 mm x 200 mm x 150 mm, three of the beams are cured conventionally and other three are self cured. Among them two of the beams are casted based on their design mix, two beams with an encased I section and two beams with barite powder as 30% replacement for fine aggregate. From the two beams casted in each type one is cured conventionally and the other beam is self cured for an detailed comparative study between conventional and self curing.

D. Test Set Up

Flexural strength tests are carried out at the 28 days cured concrete on 150 mm x 200 mm x 1200 mm beam specimen using 500 kN loading frame by subjecting the specimen to an two point loading to determine the flexural strength. Each beam specimen was tested under a simply supported loading condition. The beam was loaded by two concentrated load by means of a cross beam to provide a load on pure bending region in the central portion of the beam. Loading was applied by means of 15 ton hydraulic jack. Dial gauge of sensitivity 0.01mm were used to measure the deflection of beams. One dial was kept at the mid span of the beam and the other was kept under the point of application of load. The beams are tested up to the point of ultimate load.

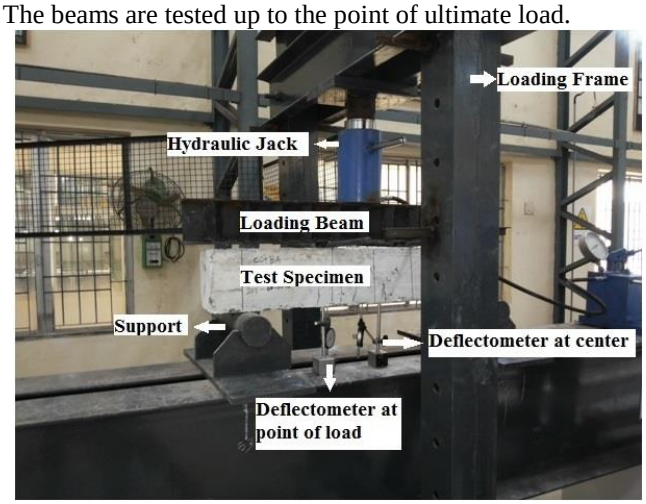

Fig. 2: Loading frame

III. RESULT AND DISCUSSION

The flexural behaviour of the concrete beam is tested using a two point load. The deflection at the centre and the point of application of load are computed and the load versus deflection curve is plotted and compared with one another in order to study their behaviour. The beams are loaded up to the point of ultimate load. The deflection at centre and point of load are noted at an interval of 8kN. The maximum deflection at ultimate load is compared between one other and maximum deflection occurs at the centre of the beam.

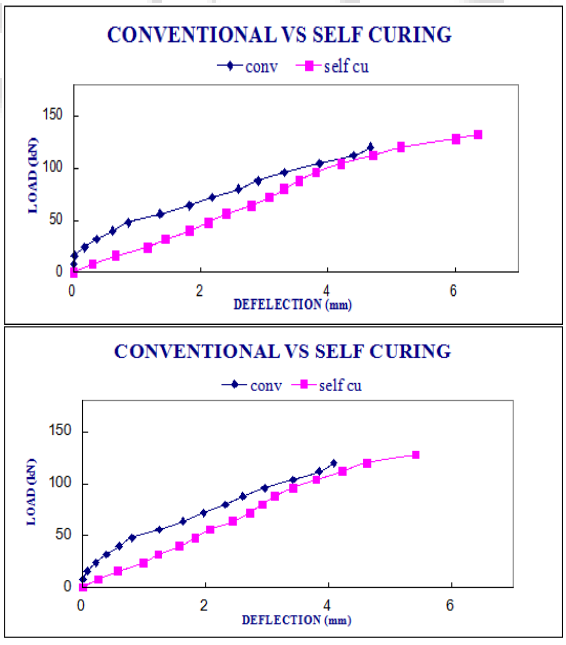

Fig. 9: Comparison between conventional and self-curing for design mix at centre and point of load respectively

On comparison between conventional and self-cured concrete beam which were casted based on their mix design the conventional concrete beam sustained an ultimate load of 116 kN and an maximum deflection of 4.67 mm occurred at centre of the beam. Whether the self-cured concrete beam bared an ultimate load of 132 kN which is 13% more than the conventionally cured concrete and maximum deflection of 5.77 mm and 6.36 mm at point of

load and centre respectively. This is the maximum deflection that occurred among all the tested beam.

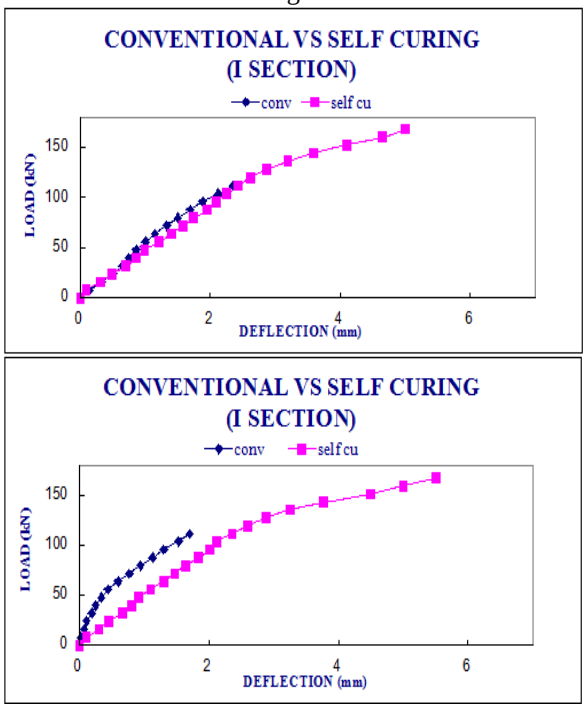

Fig. 9: Comparison between conventional and self curing with I section at centre and point of load respectively

In comparison between the conventional and self cured concrete beam with encased steel section. The self curing concrete beam seems to bare an ultimate load of 168 kN which is the maximum of all the tested beam and 50% more than the conventional concrete beam which sustained an ultimate load of 112 kN the minimum of all the beam due to sudden shear failure.

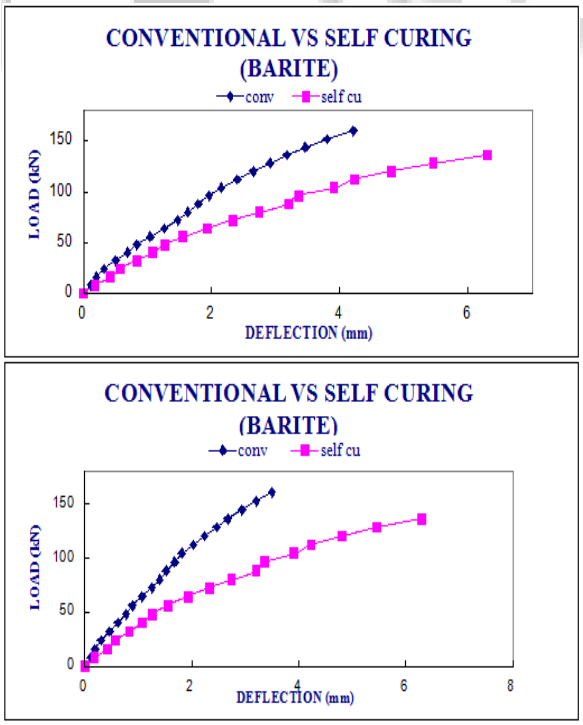

Fig. 10: Comparison between conventional and self-curing with barite at centre and point of load respectively

On comparison between these two types of beam with barite powder as 30% replacement for fine aggregate. The conventionally cured concrete beam sustained maximum load of 160 kN that is 17% more than self-cured concrete with an ultimate load of 136 kN. The self-cured concrete beam attained lesser strength than conventionally cured concrete because of the high density of barite powder it has ability to absorb water faster hence there is in-sufficient water for self curing of concrete beam.

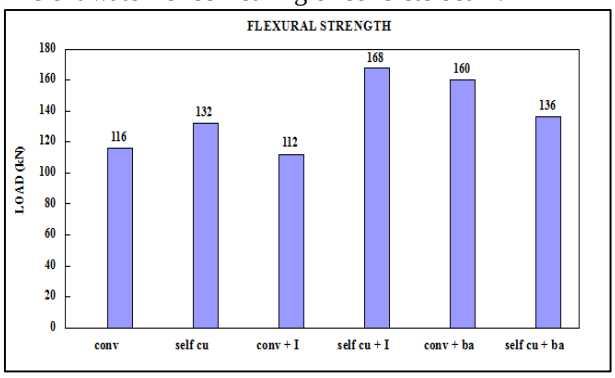

Fig. 10: Flexural strength of beams

Fig. 11: Crack pattern

IV. CONCLUSION

The various conclusions drawn from this study are as follows:

1) Poly ethylene glycol can be used as self-curing agent because of its good water retention capacity and it also seems to enhance the strength when compared to conventional concrete.
2) Barite powder as replacement for fine aggregate in concrete enhances the strength by 30 % in conventional concrete but where as in self-curing concrete there is only marginal increase in strength.
3) The self-curing concrete beam with encased steel section withstand more load than all the concrete beam and also increased the strength by 50% when compared to conventional concrete beam.

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